ELECOMP CAPSTONE SUMMIT
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THE UNIVERSITY OF RHODE ISLAND

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Roll Pitch Measurement for Sonar Geo Reference

Team Members: Cole Boulanger (CPE), Thomas Lott (ELE)

Technical Directors: Matthew Coolidge, Mike Smith

Project Motivation

FarSounder 3D forward looking sonar products feature a Transducer Module that both transmits acoustic energy and "listens" for returning echoes over an array of acoustic sensors. The received acoustic signals are digitized and processed to produce a three dimensional representation of navigation hazards in front of the vessel. The position of the Transducer Module, in particular its roll and pitch, needs to be measured so that the processed data can be displayed with appropriate geo reference.

The sensor that is currently used to measure roll and pitch is too large, and also requires manual configuration. A device called an Inertial Measurement Unit (IMU) has been introduced to the market as a single chip device that can run on a few milliamps and take up negligible circuit board real-estate. FarSounder would like to take advantage of an IMU device, which is less expensive and a physically-smaller device, by having them soldered directly to the data acquisition circuit board.

Key Accomplishments

Sensor Selection: Through research and communication with Application Engineers, the team selected four different sensors from three different manufacturers to conduct their testing upon. Key factors in the selection included sensor accuracy, data rate, and temperature sensitivity. Upon receiving sensors, the team began communication and understanding of each individual sensor. Using the evaluation software, the team was able to communicate with each sensor and output the raw data in the XYZ direction from both the accelerometer and the gyroscope. Through the use of the evaluation software and examination of sensor datasheets, the team became more confident in moving forward with the sensors that were selected.

Fabricated PCB: The team has designed and fabricated a circuit board(**Fig. 1)** that comprises all four test sensors simultaneously connecting to an Arduino Nano. The form factor of this PCB matches that of FarSounder's existing sensor. The purpose of this board is to have a simple method to mimic the roll and pitch output of the existing sensor for all sensors. Using the Arduino Nano as the processor the team is able to compute roll and pitch from some of the sensors on the PCB. This information will be fed into the DSP of the transducer module to offset the data. This PCB will be mounted inside of the transducer which will allow the sensors to be tested in a real environment. The real environment will have the added noise from other components which will allow a real look at how accurate the sensor is compared to the existing sensor.

Custom Libraries & Arduino Communication: The team has utilized a combination of presently existing sensor communication libraries, along with custom libraries modified and designed by the team, for communication between the sensors being tested, and the Arduino on the PCB. Arduino code has also been created by the team that allows for selection of a sensor to output data from via a dip switch, applies a filter to the raw data converting it into roll and pitch information, and formats the information to match the output of the existing motion sensor.(**Fig. 2)** The data is then transmitted through serial communication to header pins on the PCB at the same output data rate as the existing sensor. Therefore, the output from the test sensors is the same as the existing sensor.

Boat Test: The team has created a mount(**Fig.3)** to simultaneously log data from all four test sensors as well as the exiting sensor, where all sensors are aligned in the x-direction for maximum comparison accuracy. This mount was used during a real world environment test, on a boat at sea for a prolonged amount of time. With data from all sensors, the team has performed initial processing and analysis on the data to compare each potential solution with the existing sensor.

Data Processing Software: Multiple scripts were created in Python and MATLAB for processing purposes of the boat test data. The purpose for the Python scripts were to format each individual sensors' raw data into a suitable form from their respective evaluation software data logs. These newly formatted data logs were then input into a MATLAB script that computes the roll and pitch information from the raw data, and filters it to make the data more accurate. A hand test was also completed and processed to measure the accuracy in a controlled environment. **(Fig.4)** The purpose of the filter is to fuse the accelerator and the gyroscope data. This is done because the gyroscope has a tendency to drift over time while the accelerometer is noisy measuring the immediate data. This filter allows a correction of both issues.

Anticipated Best Outcome

The goal of this project is to design and test an Inertial Measurement Unit (IMU) that can be included in the data acquisition circuit board within the existing Transducer Module hardware package. This device will be capable of measuring roll and pitch with sufficient accuracy, precision, and speed to reflect the conditions during which the received sonar signals are sampled. To achieve this, the team must identify a suitable replacement sensor through testing, data processing, and finally analysis. Comparisons between all chosen sensors will allow the team to come to a confident solution in the choice of a replacement sensor.

Project Outcome

The Anticipated Best Outcome was achieved. The task was to evaluate and test a solid state device capable of measuring roll and pitch with sufficient accuracy, precision, and speed to reflect the conditions during which the received sonar signals are sampled.

Figures

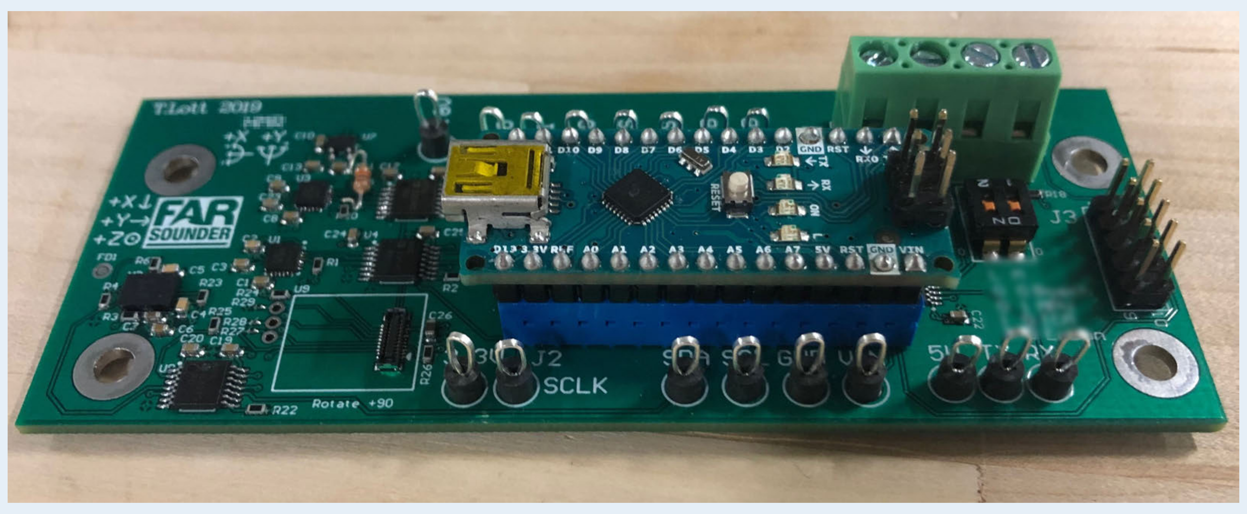

Fig. 1: Printed Circuit Board

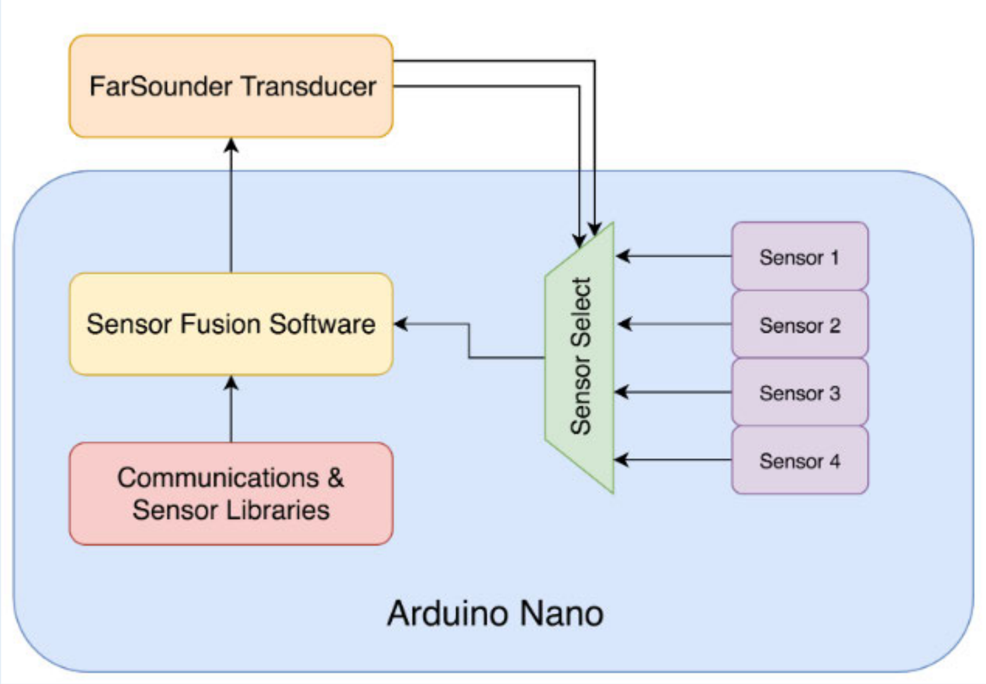

Fig 2: Arduino Code Flow Diagram

Fig 3: Boat Test Sensor Mount - Sensors Aligned for Maximum Accuracy

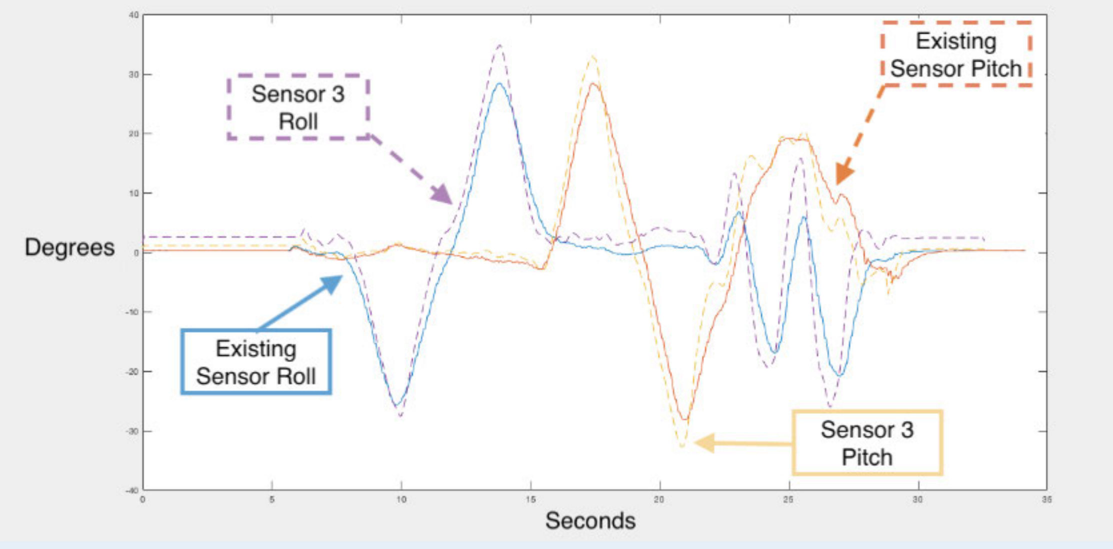

Fig. 4: Accuracy Comparison Between Sensor 3 and Existing Sensor

ELECOMP Capstone Program Director: Professor Harish R D Sunak

email: sunak@ele.uri.edu telephone: 401-874-5859 ELECOMP Website: https://uri.edu/elecomp-capstone